

Drake Passage Radiocarbon ($\Delta^{14}\text{C}$) of Dissolved Inorganic Carbon (DIC)
Measurements from Laurence M. Gould Transects
Data submission to the CDIAC

T. P. Guilderson^{1,2}, C. Sweeney^{3,4}, P. D. Quay⁵, T. Newberger³, J. Stutsman⁵

1. Center for Accelerator Mass Spectrometry, LLNL
2. Institute of Marine Sciences, University of California - Santa Cruz
3. Earth System Research Laboratory, NOAA, Boulder CO
4. Cooperative Institute for Research in Environmental Sciences, University of Colorado - Boulder
5. School of Oceanography, University of Washington, Seattle WA

LLNL-TR-562813

The following radiocarbon (^{14}C) of dissolved inorganic carbon (ΣCO_2) has been determined on samples collected during hydrographic and transect cruises of the L. M. Gould.

All samples were prepared and analyzed at the Center for Accelerator Mass Spectrometry (CAMS), Lawrence Livermore National Laboratory. Radiocarbon results are reported according to the internationally standardized nomenclature put forth in Stuiver and Polach [1977]. Results presented as fraction modern contain corrections for both background subtraction (using ^{14}C -free calcite) and $\delta^{13}\text{C}$ on splits of the same extracted CO_2 used for ^{14}C analyses and are equivalent to "F14C" [Reimer et al., 2004]. Conventional radiocarbon age (years BP) utilize the Libby half-life. Age-corrected $\Delta^{14}\text{C}$ (‰) has been determined using the date of collection. Reproducibility of the $\Delta^{14}\text{C}$ results is $\pm 2.2\text{‰}$ (1-sigma sd) based on random replicate analyses (n=30). It is this error that is reported.

Shipboard Sample Collection Methods

Samples (underway and from niskin bottles) are collected in pre-washed and baked (450°C) 250 or 500 ml ground glass- stoppered bottles using the following method. A length of Tygon tubing is attached to the Niskin bottle or seawater line and flushed for a few seconds. The end of the tubing is then placed at the bottom of the upright sample bottle and the bottle is filled, then overflowed with an amount equal to its volume if Niskin water volume permits, otherwise with at least half its volume. Flow is stopped as the Tygon tubing is removed from the top of the bottle to avoid any splashing in the top.

Using a syringe or turkey baster, 10 to 20cc are withdrawn off the top of the sample to lower the water level to approximately 1 cm below the neck of the bottle, avoiding backwash of water from the turkey baster into the sample. The ground glass joint of the bottle is wiped dry with Kimwipes. Then 100µl of a saturated HgCl_2 solution (per 250 ml of seawater) is injected beneath the surface of the sample using an Eppendorf pipette. The ground-glass stopper, which has been pre-greased with Apiezon® M grease, is then inserted straight into the bottle without twisting. If any air streaks in the grease seal are visible, the stopper is removed, cleaned, and regreased, then the bottle is resealed. Clips (if required for the neck-type of bottle) are placed on the necks of the bottles, and two heavy rubber bands are placed around the stopper and bottle to prevent leakage. The sample bottle is then inverted a couple of times to mix the HgCl_2 throughout the sample.

Laboratory Methods (Extraction, $\delta^{13}\text{C}$, $\Delta^{14}\text{C}$)

CO_2 is extracted from the DIC seawater sample using a modification of the helium stripping technique described by Kroopnick [1974] as described in Quay *et al* [1992]. The stripper is comprised of a glass tube with a stainless steel fitting and silicone-greased glass stopcock at the bottom (which connects to the He line), a glass frit which the He passes through, and a stainless steel fitting containing a 3-layer silicone rubber septum at the top. Approximately 1 ml phosphoric acid is injected into the stripper and bubbled with He for 10 minutes. The gas is then evacuated out of the stripper and the stripper is weighed. Then 80 to 125 ml of the sample is drawn into the stripper and it is weighed again to calculate the weight of water analyzed. A stainless steel needle pierces the septum and connects the stripper to the extraction line which has been evacuated and filled with helium. The sample is stripped with 99.997% pure He at a flow rate of about 200 mls/min for 20 minutes. Water is trapped out in two glass traps submerged in dewars containing a slush mixture of dry ice and isopropanol at -70°C. CO_2 is collected at -196°C in glass loop traps submerged in liquid N₂. The $\delta^{13}\text{C}$ is then measured on a Finnigan MAT 251 mass spectrometer at the University of Washington's School of Oceanography.

The efficiency of the extraction method is 100 ± 0.5 percent based on gravimetrically prepared Na₂CO₃ standards. The precision of the $\delta^{13}\text{C}$ analysis is ± 0.02 per mil based on a replicate analysis of standards and seawater samples.

Ampoules of CO_2 (sample splits) collected during stripping of DIC were shipped to the Center for Accelerator Mass Spectrometry, Lawrence Livermore National Laboratory. CO_2 was, with an optimized carbon:catalyst ratio [Graven *et al.*, 2007], quantitatively reduced to graphite in the presence of a metal catalyst [Vogel *et al.*, 1987] and pressed into individual aluminum target holders. The 14/13C ratio of each target was determined following the description presented in Guilderson *et al.*, [2006]. Individual replicate DIC samples were not available for ¹⁴C analyses. Thus, to assess analytical reproducibility and on the assumption that extraction of ΣCO_2 is 100% quantitative and no additional uncertainty was introduced (consistent with the quality of the $\delta^{13}\text{C}$ analyses), random ampoules of CO_2 were carefully split into two different graphite reduction reactors and processed/analyzed independently. Reproducibility of the $\Delta^{14}\text{C}$ results is $\pm 2.2\%$ (1-sigma sd) based on random replicate analyses ($n=30$). It is this error that is reported.

Acknowledgements

Radiocarbon analyses were funded by the NSF Office of Polar Programs (ANT-0636905). Portions of this work were performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48 and in part under Contract DE-AC52-07NA27344.

References

- Graven, H. D., T.P. Guilderson, and R.F. Keeling, 2007. Methods for high precision measurements of atmospheric CO₂ at LLNL. *Radiocarbon*, 49, 349-356.
- Guilderson, T.P., E.B. Roark, S.R. Flood Page, C. Moy, and P.D. Quay, 2006. Sea Water Radiocarbon Evolution in the Gulf of Alaska: 2002 Observations. *Radiocarbon*, 48, 1-15.
- Kroopnick, P. The dissolved O₂-CO₂-¹³C system in the eastern equatorial Pacific. *Deep-Sea Research*, 21, 211-227.
- Quay, P. D., B. Tilbrook, and C. S. Wong, 1992. Oceanic uptake of fossil fuel CO₂: C-13 Evidence. *Science*, 256, 74-79.
- Reimer, P. J., Brown, T. A., & Reimer, R. W. 2004. Discussion: Reporting and calibration of post-bomb C-14 data. *Radiocarbon*, 46(3), 1299-1304.
- Stuiver, M., and H. A. Polach, 1977. Discussion and reporting of 14C data, *Radiocarbon*, 19, 355-363.
- Vogel, J. S., J. R. Southon, and D. E. Nelson, 1987. Catalyst and binder effects in the use of filamentous graphite for AMS. *Nuclear Instruments and Methods In Physics*, B29, 50-56.

CRUISE	COL DATE	STA	CAST	NISKIN	LAT	LONG	DEPTH	Temp (°C)	PSS (salt)	BOTTLE	UW ISO#	DEL13C (%)	Graphite (prep #)	CAMS# (AMS)	Fmodern (F14C)	±Fm	14C age	±yrs	Dec Date	DELTA (%)	Average	Notes
LMG06-03	3/23/2006	6	6	1	-56.78	-64.37	3894	0.83	34.712	D-2569	I4ALMG1589	0.42	N92182	147994	0.8411	0.0021	1390	20	2006.22	-164.6	2.2	-163.7
LMG06-03	3/23/2006	6	6	1	-56.78	-64.37	3894	0.83	34.712	D-2569 split		0.42	N92271	147992	0.8429	0.0017	1375	20	2006.22	-162.8	2.2	
LMG06-03	3/23/2006	6	6	5	-56.78	-64.37	1999.4	1.77	34.724	D-2570	I3ALMG5100	0.33	N92183	147995	0.8391	0.0017	1410	20	2006.22	-166.5	2.2	
LMG06-03	3/23/2006	6	6	7	-56.78	-64.37	999.4	2.36	34.597	D-2571	I4ALMG1593	0.40	N92184	147996	0.8540	0.0017	1270	20	2006.22	-151.8	2.2	
LMG06-03	3/23/2006	6	6	11	-56.78	-64.37	300.7	3.20	34.209	D-2572	I4ALMG1540	0.97	N92185	147997	0.9388	0.0018	510	20	2006.22	-67.6	2.2	
LMG06-03	3/23/2006	6	6	14	-56.78	-64.37	99.6	3.32	34.034	D-2573	I3ALMG5125	1.06	N92186	147998	0.9742	0.0023	210	20	2006.22	-32.4	2.2	
LMG06-03	3/23/2006	6	6	16	-56.78	-64.37	49.254	5.81	33.941	D-2574	I3ALMG5078	1.62	N92187	147999	0.9756	0.0025	200	25	2006.22	-31.0	2.2	
LMG06-03	3/23/2006	6	6	17	-56.78	-64.37	24	6.26	33.911	D-2575	I4ALMG1566	1.74	N92188	148000	0.9797	0.0021	165	20	2006.22	-27.0	2.2	
LMG06-03	3/25/2006	10	10	8	-58.20	-63.89	400.1	2.84	34.171	D-2594	I4ALMG1550	0.98	N92189	148001	0.9420	0.0018	480	20	2006.23	-64.4	2.2	
LMG06-03	3/25/2006	10	10	11	-58.20	-63.89	199.9	3.16	34.044	D-2595	I4ALMG1608	1.22	N92190	148002	0.9715	0.0019	230	20	2006.23	-35.1	2.2	
LMG06-03	3/25/2006	10	10	13	-58.20	-63.89	100.2	3.61	34.031	D-2596	I4ALMG1585	1.34	N92191	148003	0.9792	0.0020	170	20	2006.23	-27.4	2.2	
LMG06-03	3/25/2006	10	10	15	-58.20	-63.89	75.6	3.69	34.024	D-2597	I3ALMG5092	1.32	N92192	148004	0.9805	0.0019	160	20	2006.23	-26.1	2.2	
LMG06-03	3/25/2006	10	10	17	-58.20	-63.98	24.07	5.86	33.922	D-2598	I3ALMG5074	1.71	N92193	148005	0.9744	0.0019	210	20	2006.23	-32.2	2.2	-32.4
LMG06-03	3/25/2006	10	10	17	-58.20	-63.98	24.07	5.86	33.922	D-2598 split		1.71	N92272	147993	0.9740	0.0023	210	20	2006.23	-32.6	2.2	
LMG06-03	3/25/2006	10	10	19	-58.20	-63.89	4.8	5.86	33.921	D-2599	I4ALMG1618	1.70	N92194	148006	0.9748	0.0019	205	20	2006.23	-31.8	2.2	
LMG06-03	3/27/2006	18	18	1	-61.04	-62.94	1001.2	1.75	34.730	D-2650	I4ALMG1592	0.34	N92200	148012	0.8499	0.0018	1305	20	2006.23	-155.9	2.2	
LMG06-03	3/27/2006	17	17	9	-60.68	-63.06	598.5	1.85	34.710	D-2644	I4ALMG1620	0.36	N92195	148007	0.8568	0.0019	1240	20	2006.23	-149.0	2.2	
LMG06-03	3/27/2006	17	17	10	-60.68	-63.05	499.6	1.88	34.682	D-2645	I4ALMG1530	0.38	N92196	148008	0.8599	0.0017	1210	20	2006.23	-145.9	2.2	
LMG06-03	3/27/2006	17	17	11	-60.68	-63.06	454.4	1.80	34.656	D-2646	I4ALMG1534	0.35	N92197	148009	0.8566	0.0018	1245	20	2006.23	-149.2	2.2	
LMG06-03	3/27/2006	17	17	13	-60.68	-63.06	298.5	1.80	34.575	D-2647	I4ALMG1536	0.32	N92198	148010	0.8652	0.0018	1165	20	2006.23	-140.6	2.2	
LMG06-03	3/27/2006	17	17	15	-60.68	-63.06	150	-0.39	34.075	D-2648	I4ALMG1625	0.77	N92199	148011	0.8875	0.0017	960	20	2006.23	-118.5	2.2	
LMG06-03	3/27/2006	18	18	13	-61.04	-62.94	25.2	3.04	33.731	D-2653	I3ALMG6094	1.77	N92201	148013	0.9258	0.0018	620	20	2006.23	-80.5	2.2	
LMG06-03	3/27/2006	18	18	15	-61.04	-62.94	4.2	3.14	33.727	D-2654	I4ALMG1588	1.82	N92202	148014	0.9316	0.0018	570	20	2006.23	-74.7	2.2	
LMG10-04	5/5/2006	UW			-56.03	-64.63	0	5.45	33.830	D5232	I3LMG7009	1.46	N97460	153622	0.9951	0.0024	40	20	2010.34	-12.1	2.4	-10.6
LMG10-04	5/5/2006	UW			-56.03	-64.63	0	5.45	33.830	D5232-split		1.46	N97846	153623	0.9982	0.0024	15	20	2010.34	-9.1	2.4	
LMG10-04	5/5/2006	UW			-56.50	-64.50	0	5.51	33.820	D5233	I3LMG7011	1.17	N97461	153621	0.9727	0.0027	>Modern		2010.34	19.8	2.7	Inadvertently not analyzed to sam
LMG10-04	5/5/2006	UW			-57.60	-64.15	0	4.93	33.810	D5235	I4LMG2371	1.11	N97462	153620	0.9918	0.0027	65	25	2010.34	-15.4	2.7	Inadvertently not analyzed to sam
LMG10-04	5/5/2006	UW			-58.00	-64.00	0	3.80	33.750	D5236	I3LMG7016	1.55	N97463	153619	0.9664	0.0026	270	25	2010.34	-40.6	2.6	Inadvertently not analyzed to sam
LMG10-04	5/5/2006	UW			-58.50	-63.85	0	3.05	33.630	D5237	I4LMG2373	1.36	N97464	153618	0.9858	0.0024	115	20	2010.34	-21.3	2.4	Inadvertently not analyzed to sam
LMG10-04	5/5/2006	UW			-59.00	-63.70	0	2.22	33.470	D5238	I3LMG6648	1.29	N97465	153617	0.9280	0.0020	600	20	2010.34	-78.7	2.0	Inadvertently not analyzed to sam
LMG10-06	9/14/2006	UW			-57.51	-65.45	0	4.751	33.950	D5472	I3LMG6993	1.15	N97778	153550	1.0033	0.0024	Modem		2010.70	-4.0	2.2	-3.9
LMG10-06	9/14/2006	UW			-57.51	-65.45	0	4.751	33.950	D5472-split		1.15	N97779	153551	1.0035	0.0022	Modem		2010.70	-3.9	2.2	
LMG08-08	6/25/2008	UW			-54.83	-64.97	0	6.447	32.864	D-3514	I4LMG2233	1.42	N92203	148188	1.0266	0.0020	>Modern		2008.48	19.4	2.2	20.6
LMG08-08	6/25/2008	UW			-54.83	-64.97	0	6.447	32.864	D-3514-split		1.42	N92273	148189	1.0291	0.0022	>Modern		2008.48	21.8	2.2	
LMG08-08	6/25/2008	UW			-55.11	-64.93	0	6.84	33.698	D-3515	I4LMG2238	1.44	N92204	148190	1.0233	0.0019	>Modern		2008.48	16.1	2.2	
LMG08-08	6/26/2008	UW			-56.04	-64.65	0	4.566	34.042	D-3516	I4LMG2231	1.46	N92205	148191	0.9947	0.0024	45	20	2008.48	-12.3	2.2	
LMG08-08	6/26/2008	UW			-56.63	-64.46	0	4.917	34.069	D-3517	I4LMG2241	1.83	N92206	148192	1.0002	0.0018	Modem		2008.48	-6.8	2.2	
LMG08-08	6/26/2008	UW			-56.63	-64.46	0	4.917	34.069	D-3517	I4LMG2242	1.32	N92207	148194	0.9981	0.0018	Modem		2008.48	-9.0	2.2	
LMG08-08	6/26/2008	UW			-58.05	-64.01	0	2.269	33.882	D-3520	I4LMG2234	1.41	N92209	148195	0.9707	0.0018	240	20	2008.48	-36.1	2.2	
LMG08-08	6/26/2008	UW			-58.71	-63.78	0	2.692	33.901	D-3521	I4LMG2240	1.44	N92210	148196	0.9653	0.0018	285	20	2008.48	-41.5	2.2	
LMG08-08	6/27/2008	UW			-60.18	-63.28	0	-0.767	33.751	D-3524	I4LMG2230	1.31	N92212	148197	0.9380	0.0022	515	20	2008.49	-68.6	2.2	-71.1
LMG08-08	6/27/2008	UW			-60.18	-63.28	0	-0.767	33.751	D-3524-split		1.31	N92276	148198	0.9331	0.0022	555	20	2008.49	-73.5	2.2	
LMG08-08	6/27/2008	UW			-60.54	-63.16	0	-0.719	33.744	D-3525	I4LMG2246	1.38	N92213	148199	0.9355	0.0017	535	20	2008.49	-71.0	2.2	
LMG08-08	6/27/2008	UW			-61.05	-62.97	0	-0.463	33.756	D-3526	I4LMG2235	1.36	N92214	148200	0.9330	0.0021	555	20	2008.49	-73.6	2.2	
LMG08-08	6/27/2008	UW			-62.11	-62.59	0	-1.168	33.748	D-3527	I4LMG2239	1.23	N92215	148201	0.9137	0.0022	725	20	2008.49	-92.7	2.2	-91.0
LMG08-08	6/27/2008	UW			-62.00	-62.63	0	-1.548	33.780	D-4452	I4LMG2248	1.32	N92216	148203	0.9315	0.0017	570	20	2008.60	-75.1	2.2	
LMG08-08	6/28/2008	UW			-61.00	-63.00	0	-1.302	33.806	D-4453	I4LMG2290	1.28	N92217	148204	0.9260	0.0017	620	20	2008.60	-80.6	2.2	-79.9
LMG08-08	6/28/2008	UW			-61.00	-63.00	0	-1.302	33.806	D-4453-split		1.28	N92277	148205	0.9275	0.0024	605	20	2008.60	-79.1	2.2	
LMG08-08	6/28/2008	UW			-60.43	-63.18	0	-1.51	33.825	D-4454	I4LMG2300	0.94	N92218	148206	0.9159	0.0018	705	20	2008.60	-90.6	2.2	
LMG08-08	6/28/2008	UW			-60.00	-63.35	0	-1.147	33.797	D-4455	I4LMG2292	1.30	N9									

CRUISE	COL DATE	STA	CAST	NISKIN	LAT	LONG	DEPTH (m)	Temp (°C)	PSS (salt)	BOTTLE	UW ISO#	DEL13C (‰)	Graphite (prep #)	CAMS# (AMS)	Fmodern (F14C)	±Fm	14C age	±yrs	Dec Date	DELTA (‰)	Average	Notes
LMG08-11	9/16/2008	UW		-58.57	-63.82	0	2.77	33.784	D-4473	I4LMG2312	1.32	N92237	148215	0.9355	0.0023	535	20	2008.71	-71.1	2.2		
LMG08-11	9/16/2008	UW		-58.98	-63.68	0	2.74	33.780	D-4474	I4LMG2314	1.33	N92238	148216	0.9362	0.0017	530	20	2008.71	-70.4	2.2		
LMG08-11	9/16/2008	UW		-59.53	-63.50	0	-1.291	33.750	D-4475	I4LMG2309	1.34	N92239	148217	0.9335	0.0017	555	20	2008.71	-73.1	2.2	-73.8	
LMG08-11	9/16/2008	UW		-59.53	-63.50	0	-1.291	33.750	D-4475 split		1.34	N92278	148219	0.9320	0.0017	565	20	2008.71	-74.5	2.2		
LMG08-11	9/17/2008	UW		-60.53	-63.15	0	-1.372	33.798	D-4477	I4LMG2317	1.29	N92241	148220	0.9207	0.0018	665	20	2008.71	-85.8	2.2		
LMG08-11	9/17/2008	UW		-62.07	-62.58	0	-1.665	33.992	D-4479	I4LMG2313	0.99	N92243	149337	0.8978	0.0017	865	20	2008.71	-108.6	2.2		
LMG09-01	1/1/2009	UW		-54.83	-64.97	0	8.087	33.070	D-4678	I4LMG2319	1.66	N92245	149338	1.0336	0.0023	>Modern		2009.00	26.2	2.2		
LMG09-01	1/1/2009	UW		-56.05	-65.48	0	5.919	34.100	D-4680	I3LMG6323	1.70	N92247	149339	0.9998	0.0020	Modern		2009.00	-7.3	2.2	-7.3	
LMG09-01	1/1/2009	UW		-56.05	-65.48	0	5.919	34.100	D-4680 split		1.70	N92278	149340	0.9998	0.0019	Modern		2009.00	-7.3	2.2		
LMG09-01	1/1/2009	UW		-56.52	-65.70	0	5.868	34.095	D-4681	I4LMG2322	1.59	N92248	148222	0.9492	0.0019	420	20	2009.00	-57.5	2.2		
LMG09-01	1/1/2009	UW		-55.00	-64.97	0	7.987	33.118	D-4679	I3LMG6307	1.65	N92246	148221	1.0272	0.0019	>Modern		2009.00	19.9	2.2		
LMG09-01	1/1/2009	UW		-57.02	-65.97	0	6.13	34.095	D-4682	I3LMG6296	1.58	N92249	149342	1.0133	0.0019	>Modern		2009.00	6.1	2.2		
LMG09-01	1/2/2009	UW		-57.48	-66.20	0	5.942	34.049	D-4683	I3LMG6321	1.54	N92250	149343	1.0032	0.0020	Modern		2009.01	-4.0	2.2		
LMG09-01	1/2/2009	UW		-58.53	-66.75	0	4.259	34.100	D-4685	I4LMG2321	1.47	N92251	149344	0.9539	0.0019	380	20	2009.01	-52.9	2.2	-54.8	
LMG09-01	1/2/2009	UW		-58.53	-66.75	0	4.259	34.100	D-4685 split	I4LMG2321-rep		N92280	149345	0.9501	0.0019	410	20	2009.01	-56.7	2.2		
LMG09-01	1/2/2009	UW		-58.98	-66.98	0	4.192	33.911	D-4686	I3LMG6316	1.11	N92252	149346	0.9673	0.0026	265	20	2009.01	-39.6	2.2		
LMG09-01	1/2/2009	UW		-60.50	-67.82	0	2.479	33.918	D-4689	I3LMG6315	1.32	N92254	148223	0.9479	0.0018	430	20	2009.01	-58.8	2.2		
LMG09-01	1/2/2009	UW		-61.00	-67.67	0	1.564	33.779	D-4690	I3LMG6324	1.15	N92255	148224	0.9341	0.0017	550	20	2009.01	-72.6	2.2		
LMG09-01	1/2/2009	UW		-62.53	-66.77	0	1.889	33.771	D-4691	I3LMG6319	1.46	N92256	148226	0.9330	0.0024	555	20	2009.01	-73.7	2.2		
LMG09-01	1/3/2009	UW		-62.62	-64.18	0	0.956	33.941	D-4692	I4LMG2320	1.39	N92257	148227	0.9118	0.0019	740	20	2009.01	-94.6	2.2		
LMG09-02	1/3/2009	UW		-61.83	-60.00	0	2.34	34.102	D-4727	I3LMG6327	1.35	N92258	148228	0.8898	0.0016	940	20	2009.01	-116.6	2.2		
LMG09-02	1/3/2009	UW		-61.00	-60.00	0	2.44	33.881	D-4728	I3LMG6329	1.54	N92259	148229	0.9156	0.0017	710	20	2009.01	-90.9	2.2		
LMG09-02	3/14/2009	UW		-58.00	-67.25	0	6.05	34.027	D-4734	I3LMG6326	1.60	N92264	149347	0.9847	0.0027	125	20	2009.20	-22.3	2.2		
LMG09-02	3/14/2009	UW		-58.00	-67.25	0	6.05	34.027	D-4734 split	I3LMG6326-REP		N94016	149348	0.9856	0.0018	115	20	2009.20	-21.4	2.2		
LMG09-02	3/15/2009	UW		-57.50	-63.98	0	5.947	34.014	D-4735	I3LMG6328	1.54	N92265	149349	0.9884	0.0019	95	20	2009.20	-18.6	2.2		
LMG09-02	3/15/2009	UW		-57.00	-63.28	0	5.777	33.995	D-4736	I3LMG6330	1.58	N92266	149350	0.9810	0.0018	155	20	2009.20	-26.0	2.2	-25.9	
LMG09-02	3/15/2009	UW		-57.00	-63.28	0	5.777	33.995	D-4736 split	I3LMG6330-REP		N94076	149351	0.9813	0.0018	150	20	2009.20	-25.7	2.2		
LMG09-02	3/15/2009	UW		-56.50	-63.57	0	4.282	33.825	D-4737	I3LMG6333	1.53	N92267	149352	0.9560	0.0017	370	20	2009.20	-51.8	2.2		
LMG09-02	3/15/2009	UW		-55.00	-64.67	0	8.46	33.691	D-4737	I3LMG6339	1.65	N92268	149353	1.0255	0.0019	>Modern		2009.20	18.2	2.2		
LMG09-02	3/15/2009	UW		-56.00	-64.82	0	5.222	33.919	D-4738	I3LMG6334	1.65	N94077	149356	0.9697	0.0028	245	20	2009.20	-37.2	2.2		
LMG09-02	3/15/2009	UW		-56.00	-64.82	0	5.222	33.919	D-4738 split	I3LMG6334-REP		N94077	149356	0.9697	0.0028	245	20	2009.20	-37.2	2.2		
LMG09-02	9/20/2009	UW		-54.80	-64.77	0	9.253	32.503	D-4738	I3LMG6340	1.57	N92270	149354	1.0296	0.0019	>Modern		2009.20	22.2	2.2		
LMG09-09	9/20/2009	10	10	2	-58.33	-63.80	3700	0.77	34.710	G-1	I3LMG6763	1.34	N97410	153310	0.8610	0.0016	1385	20				
LMG09-09	9/21/2009	13	13	3	-59.50	-63.43	3100	0.69	34.706	D-5008	I3LMG6599	0.41	N97777	153549	0.8527	0.0017	1280	20				
LMG09-09	9/19/2009	8	8	1	-57.56	-63.96	4500	1.04	34.708	D-4969	I3LMG6690	0.32	N97397	153294	0.8428	0.0020	1375	20	2009.72	-163.2	2.2	
LMG09-09	9/19/2009	8	8	6	-57.56	-63.96	1200	2.33	34.614	D-4971	I3LMG6710	0.40	N97398	153295	0.8563	0.0027	1245	20	2009.72	-149.8	2.2	
LMG09-09	9/19/2009	8	8	11	-57.56	-63.96	415	2.70	34.181	D-4972	I3LMG6711	0.94	N97400	153296	0.9335	0.0023	555	20	2009.72	-73.3	2.2	-72.3
LMG09-09	9/19/2009	8	8	11	-57.56	-63.96	415	2.70	34.181	D-4972 split		N97511	153297	0.9355	0.0019	535	20	2009.72	-71.3	2.2		
LMG09-09	9/19/2009	8	8	13	-57.56	-63.96	300	2.25	34.071	D-4973	I3LMG6694	1.14	N97401	153298	0.9478	0.0019	430	20	2009.72	-59.0	2.2	
LMG09-09	9/19/2009	8	8	16	-57.56	-63.96	80	3.76	34.063	D-4974	I3LMG6616	1.29	N97402	153299	0.9867	0.0020	110	20	2009.72	-20.4	2.2	-19.7
LMG09-09	9/19/2009	8	8	16	-57.56	-63.96	80	3.76	34.063	D-4974 split		N97512	153300	0.9861	0.0019	95	20	2009.72	-19.1	2.2		
LMG09-09	9/19/2009	8	8	19	-57.56	-63.96	5	3.76	34.064	D-4975	I3LMG6620	1.29	N97403	153301	0.9865	0.0019	110	20	2009.72	-20.6	2.2	
LMG09-09	9/20/2009	12	12	1	-59.00	-63.60	3966	0.50	34.692	D-4999	I3LMG6563	0.42	N97425	153328	0.8412	0.0016	1390	20	2009.72	-164.9	2.2	
LMG09-09	9/20/2009	10	10	1	-58.33	-63.80	3845	0.68	34.700	D-4982	I3LMG6706	0.41	N97409	153309	0.8643	0.0017	1340	20	2009.72	-159.8	2.2	
LMG09-09	9/20/2009	11	11	1	-58.67	-63.70	3840	0.68	34.701	D-4987	I3LMG6612	0.42	N97414	153314	0.8458	0.0021	1345	20	2009.72	-160.3	2.2	
LMG09-09	9/20/2009	9	9	1	-58.00	-63.90	3000	0.97	34.711	D-4976	I3LMG6700	0.42	N97404	153302	0.8449	0.0019	1355	20	2009.72	-161.2	2.2	
LMG09-09	9/20/2009	10	10	4	-58.33	-63.80	3000	0.94	34.712	D-4983	I3LMG6627	0.41	N97411	153311	0.8411	0.0017	1390	20	2009.72	-165.0	2.2	
LMG09-09	9/20/2009	12	12	2	-59.00	-63.60	3000	0.81	34.709	D-5001	I3LMG6564	0.41	N97426	153329	0.8399	0.0017	1400	20	2009.72	-168.2	2.2	
LMG09-09	9/20/2009	11	11	2	-58.67	-63.70	2999	0.88	34.711	D-4988	I3LMG6619	0.42	N97415	153315	0.8467	0.0016	1335	20	2009.72	-159.4	2.2	
LMG09-09	9/20/2009	11	11	4	-58.67	-63.70	1750	1.64	34.723	D-4989	I3LMG6724	0.40	N97416	153316	0.8456	0.0016	1345	20	2009.72	-160.5	2.2	
LMG09-09	9/20/2009	9	9	3	-58.00	-63.90	1600	2.00	34.702	D-4977 -split		N97415	153304	0.8424	0.0017	1380	20	2009.72</				

CRUISE	COL DATE	STA	CAST	NISKIN	LAT	LONG	DEPTH (m)	Temp (°C)	PSS (salt)	BOTTLE	UW ISO#	DEL13C (‰)	Graphite (prep #)	CAMS# (AMS)	Fmodern (F14C)	±Fm	14C age	±yrs	Dec Date	DELTA (‰)	Average	Notes
LMG 09-09	9/20/2009	11	11	19	-58.67	-63.70	5	-0.32	33.875	D-4998	I3LMG6562	1.24	N97424	153325	0.9468	0.0017	440	20	2009.72	-60.0	2.2	-60.7
LMG 09-09	9/20/2009	11	11	19	-58.67	-63.70	5	-0.32	33.875	D4998 - split		1.24	N97516	153326	0.9455	0.0015	450	20	2009.72	-61.3	2.2	
LMG 09-09	9/20/2009	12	12	20	-59.00	-63.60	5	-0.70	33.862	D-5006	I3LMG6549	1.28	N97430	153334	0.9484	0.0022	425	20	2009.72	-58.4	2.2	
LMG 09-09	9/21/2009	13	13	1	-59.50	-63.43	4080	0.52	34.692	D-5007	I3LMG6556	0.44	N97431	153335	0.8460	0.0020	1345	20	2009.72	-160.1	2.2	
LMG 09-09	9/21/2009	14	14	1	-60.00	-63.26	3778	0.47	34.691	D-5015	I4LMG2611	0.37	N97436	153417	0.8459	0.0014	1345	20	2009.72	-160.2	2.2	
LMG 09-09	9/21/2009	13	13	6	-59.50	-63.43	1200	2.00	34.706	D-5009	I3LMG6598	0.37	N97432	153336	0.8479	0.0017	1325	20	2009.72	-158.2	2.2	
LMG 09-09	9/21/2009	13	13	12	-59.50	-63.43	160	0.92	34.078	D-5012	I3LMG6587	0.99	N97433	153337	0.9251	0.0016	625	20	2009.72	-81.6	2.2	-79.6
LMG 09-09	9/21/2009	13	13	12	-59.50	-63.43	160	0.92	34.078	D5012 - split		0.99	N97516	153338	0.9291	0.0016	590	20	2009.72	-77.6	2.2	
LMG 09-09	9/21/2009	13	13	17	-59.50	-63.43	30	-0.55	33.851	D-5013	I3LMG6588	1.24	N97434	153339	0.9412	0.0017	485	20	2009.72	-65.6	2.2	
LMG 09-09	9/21/2009	13	13	20	-59.50	-63.43	5	-0.56	33.851	D-5014	I3LMG6586	1.29	N97435	153416	0.9504	0.0016	410	20	2009.72	-56.4	2.2	
LMG 09-09	9/22/2009	16	16	1	-61.00	-62.92	3774	0.47	34.692	D-5027	I3LMG6561	0.42	N97441	153421	0.8482	0.0015	1325	20	2009.72	-157.9	2.2	
LMG 09-09	9/22/2009	16	16	3	-61.00	-62.92	2200	0.94	34.715	D-5028	I3LMG6592	0.42	N97442	153422	0.8463	0.0015	1320	20	2009.72	-157.8	2.2	
LMG 09-09	9/22/2009	16	16	5	-61.00	-62.92	800	2.03	34.696	D-5029	I3LMG6583	0.38	N97443	153423	0.8640	0.0033	1175	20	2009.72	-142.3	2.2	
LMG 09-09	9/22/2009	16	16	7	-61.00	-62.92	500	2.08	34.615	D-5030	I4LMG2605	0.18	N97444	153424	0.8638	0.0015	1175	20	2009.72	-142.4	2.2	-142.6
LMG 09-09	9/22/2009	16	16	7	-61.00	-62.92	500	2.08	34.615	D5030 split		0.18	N97520	153425	0.8634	0.0016	1180	20	2009.72	-142.8	2.2	
LMG 09-09	9/22/2009	15	15	10	-60.50	-63.09	400	2.15	34.553	D-5023	I3LMG6608	0.39	N97437	153436	0.8753	0.0019	1070	20	2009.72	-131.0	2.2	
LMG 09-09	9/22/2009	16	16	10	-61.00	-62.92	250	1.75	34.426	D-5031	I3LMG6566	0.50	N97445	153426	0.8822	0.0016	1005	20	2009.72	-124.1	2.2	
LMG 09-09	9/22/2009	16	16	12	-61.00	-62.92	160	1.08	34.264	D-5032	I3LMG6538	0.64	N97446	153427	0.9015	0.0026	835	20	2009.72	-105.0	2.2	
LMG 09-09	9/22/2009	15	15	13	-60.50	-63.09	120	-1.63	33.945	D-5024	I3LMG6609	1.16	N97438	153437	0.9275	0.0017	605	20	2009.72	-79.1	2.2	
LMG 09-09	9/22/2009	15	15	15	-60.50	-63.09	75	-1.62	33.943	D-5025	I3LMG6603	1.16	N97439	153418	0.9185	0.0016	685	20	2009.72	-88.2	2.2	-84.5
LMG 09-09	9/22/2009	15	15	15	-60.50	-63.09	75	-1.62	33.943	D5025 split		1.16	N97516	153419	0.9259	0.0017	620	20	2009.72	-80.8	2.2	
LMG 09-09	9/22/2009	16	16	14	-61.00	-62.92	75	-1.74	33.912	D-5033	I3LMG6579	1.20	N97447	153428	0.9257	0.0017	620	20	2009.72	-81.0	2.2	
LMG 09-09	9/22/2009	15	15	18	-60.50	-63.09	5	-1.62	33.942	D-5026	I3LMG6595	1.14	N97440	153420	0.9226	0.0016	645	20	2009.72	-84.0	2.2	
LMG 09-09	9/22/2009	16	16	18	-61.00	-62.92	5	-1.78	33.892	D-5034	I3LMG6597	1.22	N97448	153429	0.9303	0.0019	580	20	2009.72	-76.4	2.2	
LMG 09-09	9/23/2009	20	20	1	-63.00	-62.24	850	0.48	34.606	D-5052	I3LMG6629	1	N97453	153431	0.8607	0.0016	1205	20	2009.73	-145.5	2.2	
LMG 09-09	9/23/2009	20	20	3	-63.00	-62.24	700	0.74	34.622	D-5054	I3LMG6631	0.45	N97454	153432	0.8644	0.0022	1170	20	2009.73	-141.8	2.2	
LMG 09-09	9/23/2009	19	19	6	-62.50	-62.41	150	-0.60	34.290	D-5050	I3LMG6543	0.70	N97451	153430	0.8815	0.0018	1015	20	2009.73	-124.8	2.2	
LMG 09-09	9/23/2009	20	20	11	-63.00	-62.24	150	-1.02	34.245	D-5055	I3LMG6632	0.73	N97455	153433	0.8878	0.0016	955	20	2009.73	-118.6	2.2	
LMG 09-09	9/23/2009	18	18	14	-62.00	-62.58	25	-1.80	34.014	D-5046	I3LMG6650	1.06	N97449	153552	0.8532	0.0022	1275	20	2009.73	-152.9	2.2	
LMG 09-09	9/23/2009	20	20	16	-63.00	-62.24	10	-1.76	34.098	D5056 split		0.82	N97456	153434	0.8941	0.0016	900	20	2009.73	-112.4	2.2	-114.5
LMG 09-09	9/23/2009	20	20	17	-63.00	-62.24	5	-1.76	34.098	D-5057	I3LMG6696	0.84	N97457	153553	0.9029	0.0019	820	20	2009.73	-103.6	2.2	
LMG 10-04	5/5/2010	UW			-54.62	-64.95	0	7.88	32.340	D-5230	I3LMG6855	1.53	N97458	153554	1.0329	0.0022	>Modern	2010.34	25.4	2.2		
LMG 10-04	5/5/2010	UW			-55.00	-64.95	0	7.74	32.130	D-5231	I3LMG7008	1.10	N97459	153555	1.0362	0.0022	>Modern	2010.34	26.7	2.2		
LMG 10-04	5/7/2010	UW			-60.02	-63.33	0	0.27	33.480	D-5240	I3LMG7010	1.10	N97467	153511	0.9335	0.0024	550	20	2010.35	-73.3	2.2	
LMG 10-04	5/7/2010	UW			-60.52	-63.17	0	0.42	33.500	D-5241	I3LMG6850	1.43	N97468	153531	0.9315	0.0019	570	20	2010.35	-75.3	2.2	
LMG 10-04	5/7/2010	UW			-61.00	-62.98	0	-0.18	33.520	D-5242	I3LMG7012	1.19	N97439	153529	0.9309	0.0029	580	20	2010.35	-76.5	2.2	-76.8
LMG 10-04	5/7/2010	UW			-61.00	-62.98	0	-0.18	33.520	D5242-split		1.19	N97843	153530	0.9296	0.0019	585	20	2010.35	-77.1	2.2	
LMG 10-04	5/7/2010	UW			-62.00	-62.62	0	-0.49	33.490	D-5243	I3LMG7015	1.10	N97470	153532	0.9253	0.0020	625	20	2010.35	-81.4	2.2	-81.6
LMG 10-04	5/7/2010	UW			-62.00	-62.62	0	-0.49	33.490	D5243-split		1.10	N97844	153533	0.9250	0.0018	625	20	2010.35	-81.8	2.2	
LMG 10-06	9/14/2010	UW			-54.97	-64.97	0	6.08	32.754	D-5467	I3LMG6988	1.37	N97472	153512	1.0264	0.0020	>Modern	2010.70	18.9	2.2		
LMG 10-06	9/14/2010	UW			-55.03	-64.97	0	6.04	32.837	D-5468	I3LMG6989	1.38	N97473	153513	1.0267	0.0020	>Modern	2010.70	19.2	2.2		
LMG 10-06	9/15/2010	UW			-56.00	-65.15	0	4.56	34.014	D-5469	I3LMG6990	1.34	N97474	153514				2010.70			Ran Poorly No RESULT	
LMG 10-06	9/15/2010	UW			-56.00	-65.15	0	4.56	34.014	D5469-split		1.34	N97522	153515	1.0084	0.0022	Modern	2010.70	1.0	2.2		
LMG 10-06	9/15/2010	UW			-57.00	-65.35	0	4.46	34.010	D-5471	I3LMG6995	1.29	N97476	153516	1.0071	0.0022	Modern	2010.70	-0.3	2.2		
LMG 10-06	9/15/2010	UW			-58.00	-65.55	0	4.90	33.929	D-5473	I3LMG6997	1.04	N97477	153517	1.0100	0.0027	Modern	2010.70	2.6	2.2		
LMG 10-06	9/15/2010	UW			-58.51	-65.65	0	4.24	33.998	D-5474	I3LMG6992	1.21	N97478	153518	0.9990	0.0020	Modern	2010.70	-8.3	2.2		
LMG 10-06	9/15/2010	UW			-59.02	-67.76	0	3.84	33.971	D-5475	I3LMG6996	1.15	N97479	153519	0.9859	0.0020	115	20	2010.70	-21.3	2.2	
LMG 10-06	9/16/2010	UW			-60.02	-65.96	0	0.82	33.832	D-5477	I3LMG6999	1.09	N97480	153520	0.9549	0.0019	370	20	2010.71	-52.1	2.2	
LMG 10-06	9/16/2010	UW			-61.01	-66.17	0	-1.55	33.624	D-5479	I3LMG7004	1.17	N97481	153521	0.9475	0.0019	435	20	2010.71	-59.4	2.2	
LMG 10-06	9/16/2010	UW			-62.01	-66.40	0	-1.72	33.751	D-5480	I3LMG7007	0.94	N97482	153522	0.9188	0.0019						

<u>CRUISE</u>	<u>COL DATE</u>	<u>STA</u>	<u>CAST</u>	<u>NISKIN</u>	<u>LAT</u>	<u>LON</u>	<u>DEPTH</u>	<u>Temp</u> (°C)	<u>PSS</u> (salt)	<u>BOTTLE</u>	<u>UW ISO#</u>	<u>DEL13C</u> (‰)	<u>Graphite</u> (prep #)	<u>CAMS#</u> (AMS)	<u>Fmodern</u> (F14C)	<u>±Fm</u>	<u>14C age</u>	<u>±yrs</u>	<u>Dec Date</u>	<u>DELTA</u> (‰)	Average	<u>Notes</u>
LMG 10-08	11/3/2010	UW		-61.83	-61.18	0	-0.82	33.201	D5510	I3LMG6979	1.16	N97509	153547	0.9229	0.0020	645	20	2010.84	-83.9	2.2	-80.5	
LMG 10-08	11/3/2010	UW		-61.83	-61.18	0	-0.82	33.201	D5510-split		1.16	N97776	153548	0.9297	0.0018	585	20	2010.84	-77.1	2.2		